Water Quality, Water Savings and the Water–Energy Nexus
Three Issues, One Solution?

By
Part 3 – Tim Keane
Legionella Risk Management, Inc. Inc.

Email: timke@Verizon.net
For the first time, this MMWR Surveillance Summary includes drinking water–associated outbreaks of Legionnaires disease (LD); six outbreaks of LD occurred during 2001--2002.
Legionella was implicated in 66% outbreaks, 89% hospitalizations, and 100% deaths.

Although the total number of drinking water–associated outbreaks has remained nearly constant, Legionella has caused increasing proportions of drinking water–associated outbreaks (33%, 60%, and 66% during each of these time periods, respectively). This pattern has been driven by the increasing proportion of Legionella outbreaks among those in community water systems (60%, 76%, and 84% during each of these time periods, respectively).
CDC Data

National Incidence of Legionellosis, 1998-2012

Incidence per 100,000 pop.

Year
Key Issues

- Why OPPPs, Why Now?
- Taking Responsibility for OPPPs
- OPPPs in green buildings
CDC Reported DW Outbreaks 1971 – 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>Water Consumption Flattens</td>
</tr>
<tr>
<td>1979</td>
<td>CPSC recommends 130°F home water heaters</td>
</tr>
<tr>
<td>1987</td>
<td>SD 1st US Legionella</td>
</tr>
<tr>
<td>1987</td>
<td>NAECA Nat'l Appliance Energy Conserv Act</td>
</tr>
<tr>
<td>1989</td>
<td>ASHRAE 90.1</td>
</tr>
<tr>
<td>1992</td>
<td>EPA NAECA</td>
</tr>
<tr>
<td>1997</td>
<td>ACHD Legionella Guidelines</td>
</tr>
<tr>
<td>1998</td>
<td>OSHA Legionella Guideline</td>
</tr>
<tr>
<td>1998</td>
<td>USGBC LEED</td>
</tr>
<tr>
<td>2001</td>
<td>Joint Commission Standard</td>
</tr>
<tr>
<td>2003</td>
<td>1st CDC guidelines</td>
</tr>
<tr>
<td>2004</td>
<td>1st CDC Legionella MMWR</td>
</tr>
<tr>
<td>2004</td>
<td>Wisconsin Plumbing Code</td>
</tr>
<tr>
<td>2007</td>
<td>EPA Water Sense</td>
</tr>
</tbody>
</table>

**FIGURE.** Etiology of 885 drinking water–associated outbreaks, by year — United States, 1971–2012*
1970  46

U.S. Water Consumption Flat since 1970

Source: Figure prepared by PH Gleick; data from USGS and USBEA, 2014.
11.4.5.2 Lavatories in public facility restrooms (such as those in service stations, airports, train terminals, and convention halls) shall meet all of the following requirements:

(a) **Flow Rate,** Be equipped to limit the flow of hot water to
   1. either a maximum of 0.50 gpm,
   2. or 0.75 gpm if a device or fitting is used that limits the period of water discharge, such as a foot switch or fixture occupancy sensor,
   3. or 2.5 gpm if equipped with a self-closing valve.

(b) **Total Flow,**
   1. Either be equipped with a foot switch or fixture occupancy sensor or similar device
   2. or be equipped with a device or fitting that limits delivery to a maximum of 0.25 gallons per cycle of hot water for circulating systems and a maximum of 0.50 per cycle gallons for non-circulating systems. Lavatories for physically handicapped persons need not be so equipped.

(c) **Temperature,** Limit the outlet temperature to 110°F maximum.
If a facility uses hot water storage tanks, raise the water temperature of all domestic hot water storage tanks to a minimum of 140 degrees Fahrenheit (°F) to prevent growth of Legionella. A master thermostatic mixing valve assembly must be installed on the discharge side to reduce water temperature to 130°F before distribution, with a maximum decrement in water temperature of 10°F (120°F) at the tap.
SPIKE IN LEGIONNAIRES’ DISEASE IN GENESSEE COUNTY

The State of Michigan reported a spike in cases of Legionnaires’ disease in Genesee County from June 2014 to October 2015 — a total of 88. There were 10 reported fatalities associated with this increase.

CASES OF LEGIONNAIRES’ DISEASE IN GENESSEE COUNTY, BY MONTH

<table>
<thead>
<tr>
<th>Month</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>11</td>
<td>13</td>
<td>8</td>
<td>41</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

LEGIONNAIRES’ DISEASE: PNEUMONIALIKE DISEASE CAUSED BY BACTERIA

Legionnaires’ disease is caused by the Legionella bacterium, which is usually found in water. The disease is associated with manmade water environments including hot tubs, large plumbing systems and cooling towers. Many infections go undiagnosed or unreported because symptoms are similar to pneumonia.

HISTORY
The disease got its name after an outbreak at the 1976 Philadelphia convention of the American Legion.

SYMPTOMS
Symptoms include fever, chills and cough.

EXPOSURE AND TRANSFER
Infection occurs when a person breathes in water vapor containing the bacteria; it does not transfer between people.

INCUBATION PERIOD
2 to 10 days after exposure.

PERCENT WHO BECOME ILL WHEN EXPOSED TO SOURCE
Less than 5%.

OUTCOME
Need for hospitalization is common. Fatality rate is 5-30%.

SOURCES: Michigan Department of Health and Human Services, U.S. Centers for Disease Control and Prevention, Emory University, U.S. National Institutes of Health

KRISTI TANNER and MARTHA THIERRY/DETROIT FREE PRESS, TRIBUNE NEWS SERVICE
Southfield lawyer Geoffrey Fieger filed a $100–million lawsuit today against McLaren Flint Hospital and the State of Michigan, saying they did nothing to combat an outbreak of Legionnaires' disease that killed at least one person during the Flint water crisis.

(/story/news/local/michigan/flint-water-crisis/2016/01/22/legionnaires-expert-blames-spike-cases-flint-water/79203614/)
2012 Water Quality Technology Conference – Toronto, ON Canada
Nov 6, 2012

Case Studies of Legionnaires' Disease Outbreaks Related to Municipal Water Disruptions

Tim Keane, Legionella Consulting Engineer
Legionella Risk Management, Inc., Chalfont, PA
Legionellosis: Risk Management for Building Water Systems

Standard committee members included personnel from following groups / associations:

- CDC
- ASHE
- ASPE
- APIC
- AWT
- GSA
- IAPMO
- NSF
- PMI and
- Major Equipment Manufacturers
- Large Corporations
- Consulting Engineers
National Priorities: Impacts of Water Conservation on Water Quality in Premise Plumbing and Water Distribution Systems

Solicitation Opening Date: February 1, 2016

U.S. Environmental Protection Agency
Office of Research and Development
National Center for Environmental Research
2016 – EPA Commissions Study on Negative Impact of Water Use Reduction

8 years after Legionella becomes responsible for over 33% of DW outbreaks in 2008, then over 50% in 2009.
Key Issues

- Why OPPPs, Why Now?
- Taking Responsibility for OPPPs
- OPPPs in green buildings
- **Public Health**
  - CDC
  - EPA
  - CMS
  - Joint Commission
  - CSP
- **Building Design**
  - Architectural Design
  - Plumbing System Design
  - Plumbing Component Selection
- **Plumbing Code**
  - Higher Temperatures
  - Less pipe runs
  - Smaller diameter pipes
Engineering Control Strategies

1) Limiting Nutrient Strategies (e.g., AOC)
2) Secondary Residual Type and Dose
3) Upgrade Water Mains
4) Water Heater Set Point
5) In-Building Disinfection
6) Thermal Shock Treatments
7) Pipe Material Selection
8) Flow Control
9) Heater Selection
10) Water Age
Conclusions:

- Solutions that can be implemented by utilities
  - Maintaining higher chlorine residuals
  - Upgraded infrastructure
- Solutions that can be implemented by building owners
  - Higher temperatures
  - In building disinfection
  - Flow velocity control
  - Heater type and operation
  - Water age
Unintended Consequences of Plumbing Codes and Regulations on Increasing Rates of Legionnaire’s Disease

By
Tim Keane
Legionella Risk Management, Inc.

www legionellae org
www linkedin com in legionella
What happens when adding 0.5 gpm flow restriction to a ¾” pipe?
So what happens when we:

- Decrease flow rates at distal sites (reduced from 2.2 to 0.5 gpm)
- Decrease temperatures at distal sites (reduced from >120 to <110°F)
- Maintain drop leg volume constant (no change in pipe diameters or drop leg length) (gal)
## Turnover rate of a Drop Leg Reducing Water Age Volume: 1 gallons

<table>
<thead>
<tr>
<th>Flow Rate (GPM)</th>
<th>Minutes (Min) / Drop Leg Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>0.4 (24 sec)</td>
</tr>
<tr>
<td>2</td>
<td>0.5 (30 sec)</td>
</tr>
<tr>
<td>1</td>
<td>1 (60 sec)</td>
</tr>
<tr>
<td>0.5</td>
<td>2 (120 sec)</td>
</tr>
</tbody>
</table>

“To the optimist, the glass is half full. To the pessimist, the glass is half empty. To the engineer, the glass is twice as big as it needs to be.” — Unknown
# How Long Should We Wait?

<table>
<thead>
<tr>
<th>Volume in the Pipe (ounces)</th>
<th>Minimum Time-to-Tap (seconds) at Selected Flow Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.25 gpm</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>24</td>
<td>45</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
</tr>
<tr>
<td>64</td>
<td>120</td>
</tr>
<tr>
<td>128</td>
<td>240</td>
</tr>
</tbody>
</table>

**ASPE Time-to-Tap Performance Criteria**

- **Acceptable Performance**: 1 – 10 seconds
- **Marginal Performance**: 11 – 30 seconds
- **Unacceptable Performance**: 31+ seconds

**Pipe Diameter (inches)** | **Volume (gal) 20’ drop leg** | **Velocity (fps) @ 1 gpm**
---|---|---
1 | 0.9 | 0.4
3/4 | 0.56 | 0.73
1/2 | 0.32 | 1.6
3/8 | 0.1 | 3

“To the optimist, the glass is half full. To the pessimist, the glass is half empty. To the engineer, the glass is twice as big as it needs to be.” — Unknown
<table>
<thead>
<tr>
<th>Plumbing Fixture</th>
<th>Maximum Discharge Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bidet</td>
<td>110°F</td>
</tr>
<tr>
<td>Public Hand washing Stations</td>
<td>85°F to 110°F</td>
</tr>
<tr>
<td>Showers</td>
<td>120°F</td>
</tr>
<tr>
<td>Bathtub / Whirlpool Bathtub</td>
<td>120°F</td>
</tr>
<tr>
<td>Temperature</td>
<td>Growth Rate</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>&lt;77°F (25°C)</td>
<td>no growth</td>
</tr>
<tr>
<td>72°F (22°C) to 86°F (30°C)</td>
<td>slow growth</td>
</tr>
<tr>
<td>86°F (30°C) to 110°F (43°C)</td>
<td>rapid growth</td>
</tr>
<tr>
<td>110°F (43°C) to 122°F (50°C)</td>
<td>slow growth</td>
</tr>
<tr>
<td>&gt; 122°F (50°C)</td>
<td>no growth</td>
</tr>
<tr>
<td>&gt; 130°F (55°C)</td>
<td>die in hours</td>
</tr>
<tr>
<td>&gt; 140°F (60°C)</td>
<td>die in minutes</td>
</tr>
<tr>
<td>&gt; 160°F (71°C)</td>
<td>die in seconds</td>
</tr>
</tbody>
</table>
# Handwashing Sink Risk Analysis

Temperatures between 85–110°F are a very high risk and should **not** be recommended in code.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Name</th>
<th>Scald Risk</th>
<th>Scald Time (sec)</th>
<th>Legionella Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 77°F</td>
<td>Cold</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>77°F – 85°F</td>
<td>Tepid Cold</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>85°F – 110°F</td>
<td>Tepid</td>
<td>No</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>110°F – 122°F</td>
<td>Warm</td>
<td>No</td>
<td>60</td>
<td>Moderate</td>
</tr>
<tr>
<td>122°F – 131°F</td>
<td>Tempered</td>
<td>Very Low</td>
<td>5</td>
<td>Low</td>
</tr>
<tr>
<td>131°F – 140°F</td>
<td>Hot</td>
<td>Moderate</td>
<td>2</td>
<td>Very Low</td>
</tr>
<tr>
<td>140°F – 160°F</td>
<td>Very Hot</td>
<td>High</td>
<td>Instant</td>
<td>No</td>
</tr>
<tr>
<td>&gt; 160°F</td>
<td>Disinfecting</td>
<td>Instant</td>
<td>Instant</td>
<td>No</td>
</tr>
</tbody>
</table>

Temperatures between 122 – 131°F are a very low risk and should be recommended in code.
Hot Water Burn & Scalding Graph

Boiling Point
100 °C | 212 °F

Time/Temperature to Produce 2nd & 3rd Degree Burns*

Data compiled by Accurate Building Inspectors

AOS = A.O. Smith (Water Products Company)
ABA = American Burn Association
CPSC = Consumer Product Safety Commission
DV = Burn Foundation of Delaware Valley
UM = University of Michigan Health System
VA = Department of Veterans Affairs

1-800-640-8285 www.AccurateBuilding.com

Date: December 15, 2005

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New York City
San Francisco

Clifton Clark, General Manager
SAN FRANCISCO AIRPORT MARRIOTT WATERFRONT
Domino Effect of ASHRAE 188 on Waterborne Pathogens, Legionella and Plumbing Systems

Tim Keane
Consulting Engineer
Legionella Risk Management, Inc.
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Domino effect

- On industry – general contractors and building owners will ask for design criteria to minimize the risk of Legionella colonization.
- On Plumbing system designers
- On equipment manufacturers.
- On litigation / liability risk for contractors and manufacturers.
- ON PLUMBING CODE CHANGES
Building Water System Design
Series innovation to reduce stagnation

Flow Through Fittings – Series

With a Series Installation, every time a fixture is operated, fresh water flows through the supply piping of every fixture upstream of the fixture used.

Whenever possible, the most frequently used fitting should be installed at the end of the series.
Design Strategies

Thermostatic Recirc. Valve
Design Strategies

Internal Recirculation
Design Strategies

- Less Piping
- Smaller Circulator
- Saves Energy
- Saves Water
- Saves Material (Hangers, Fire Stops, Insulation)
- ProPress
- Fast Installation
- Less Material & Installation Cost compared to a two pipe system
- Innovative
OnDemand Tankless Heater

Commercial
✓ Remote fixtures eliminating hot water lines
✓ Low use such as school sinks.

Residential
✓ Stand alone
✓ Extra capacity
✓ Downstream of solar system
The Eye Pod
“Here is Edward the Bear, coming downstairs now, bump, bump, bump, bump, on the back of his head, behind Christopher Robin. It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there is really another way, if only he could stop bumping for a moment and think of it.”
Water Quality, Water Savings and the Water–Energy Nexus
Three Issues, One Solution? Absolutely!

This group of Academic, Energy and Legionella Experts Strongly Agree

Water and energy saving measures, well designed, will not facilitate OPPP’s, but rather can reduce their risk. But we need several things, most importantly code changes for temperature and pipe sizing.

By
Marc Edwards, Gary Klein & Tim Keane